TESTIMONY

Strengthening Research & Development for Wind Hazard Mitigation

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RAND CORPORATION

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Strengthening Research & Development for Wind Hazard Mitigation*
Before the Committee on Science of the U.S. House of Representatives
Strengthening Windstorm Hazard Mitigation: An Examination of Public and Private Efforts
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Mr. Chairman: I am pleased to be here to day to discuss the research and findings from the recent RAND report "Assessing Federal Research and Development for Hazard Loss Reduction." This work was carried out at the request of the Office of Science and Technology Policy to help formulate a better understanding of the role of government-sponsored R&D in the nation's efforts to reduce hazard losses. For this task, RAND conducted an analysis of the full range of federal R&D expenditures guided by the following questions

- What is the distribution of federal R&D funding across various types of hazards?
- What types of research activities are supported by federal funding?
- What criteria determine the allocation of these funds?
- How do these R&D efforts contribute to hazard loss reduction?

With this approach we carried out an analysis to determine whether there are holes or imbalances in the Federal R&D portfolio and whether key areas are being overlooked. We used the results of our analysis to develop a policy framework that will help in future attempts to assess the "payoffs" of various kinds of R&D, including which efforts offer the greatest potential for reducing hazard losses. Finally, we considered the larger issues about the demands placed on R&D to "solve" the problem of hazard losses. Ultimately, we offered suggestions for new ways to frame expectations and demands for R&D in addressing the problem of hazard losses.

The RAND study was motivated by the problem of rapidly growing economic losses from natural hazards. While the United States has experienced a decline in the numbers of lives lost due to earthquakes, hurricanes, floods, tornados, and droughts, over the past few decades, the associated costs of natural disasters escalated dramatically over the same period. Between 1978 and 1989, the Federal Emergency Management Agency (FEMA) paid out about $7 billion in disaster relief funds. In the next dozen years, however, payouts increased almost fivefold, to over $39 billion.

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The primary cause for the rise appears to be growing population in vulnerable areas. Demographic changes, most dramatically, the mass human migration to coastal and other high-risk areas, have made disasters increasingly costly events. At the same time, increasing concentrations of people and property have escalated the complexity of the nation's infrastructure—public utilities, critical facilities, transportation systems, communications networks, and the built environment. As the density of the infrastructure increases, particularly in urban areas, the potential losses from natural hazards become greater still.

Because of the heavy financial burden imposed by losses across all sectors of the economy, pressure on the federal government to act quickly and effectively to "solve" the problem has been growing. With this motivation, the federal strategy to address the hazard loss problem takes many forms, from providing disaster relief to assisting in the regulation of private insurance to encouraging mitigation efforts through various incentives. A key weapon in the federal government's arsenal is its support of research and development (R&D). Specifically, it funds work carried out by the research community to improve understanding of, preparation for, and response to hazards and their impacts.

To answer the questions posed by OSTP, we needed a clear view of hazard loss reduction efforts in the federal R&D portfolio. We therefore conducted an analysis of the federal R&D portfolio for a particular year, FY 2001. Our objective was to identify R&D expenditures that support the goals of reducing losses from natural hazards such as floods, hurricanes, earthquakes, and wildfires. Because the federal budget does not have a separate R&D budget, much less one focused solely on hazard loss, we had to develop a set of detailed criteria to identify hazard loss R&D activities within larger research programs across the federal government.

Our data sources were RAND's RaDiUS database and other sources of federal budget information. (RaDiUS stands for research and development in the United States and it includes all federally funded R&D expenditures.) The RaDiUS database details all federal R&D funding as determined by computer records from the Office of Management and Budget (OMB). We also looked at individual agency budget requests, as well as annual R&D reports generated by the Office of the Federal Coordinator for Meteorology, which encompasses the broad range of weather-related federal programs.

Using these sources, we were able to analyze funding from a number of perspectives, quantifying expenditures by agency, hazard type, and program goals. Our key findings were as follows:

- *Explicit hazard loss reduction programs receive the least funding.* Programs dedicated solely to hazard loss reduction R&D receive the smallest share of R&D funds. The largest fraction goes to basic and applied research programs at the National Science Foundation (NSF), the National Oceanic and Atmospheric Administration (NOAA), and the National Aeronautics and Space Administration

(NASA). The second largest category is operational support R&D, focused almost exclusively on weather-related hazards.

- *The largest fraction of R&D spending supports work on weather hazards and broadly related research on climatology, atmospheric science, and oceanography.* The second largest category of R&D funding—a distant second—is research on earthquakes. While losses from weather-related hazards are estimated to be approximately twice as large as those from earthquakes, the allocation of R&D funds between these categories differs by more than a factor of 10.

- *Much of the R&D spending supports short-term prediction capabilities.* Closer examination of the funding for weather-related hazard R&D shows that most of the effort is focused on short-term prediction efforts, which have limited loss reduction potential within the full range of losses from natural hazards. Prediction can generally move individuals out of harm's way, but R&D focused on long-term loss reduction strategies could improve the resilience of communities and infrastructure, protecting lives and property in a far more substantial way.

This emphasis on weather-related hazards and prediction means that other areas of hazard R&D receive comparatively less attention. However, decisionmaking in this policy environment is difficult. Despite its investments in hazard loss reduction R&D, the government has yet to establish the essential framework that would enable these efforts to operate efficiently and show their own merit. Developing a more thoughtful strategy for funding allocation depends on the ability to accurately determine the losses resulting from hazards and the losses prevented or reduced by R&D efforts. In turn, it also depends on the willingness of individuals and communities to implement measures designed to reduce hazard losses. In other words, decisionmakers face both quantitative and qualitative challenges in seeking to strengthen the effectiveness of federal hazard loss R&D efforts.

First and foremost among these challenges is the lack of detailed data on losses from natural hazards. (This quantitative gap has been identified and examined in a number of previous policy studies.) Without such data, it is impossible to gauge either the effectiveness of new R&D strategies or their ultimate payoff in terms of losses prevented. Detailed loss data would go a long way toward enabling a more cost-effective distribution of R&D funds.

From a qualitative standpoint, perhaps the most daunting obstacle policymakers face is human nature. Human behavior ultimately controls the scale of disaster losses and thus exerts a major force on R&D policy decisions for hazard loss reduction. While R&D provides useful technical information, its effectiveness is determined by human decisionmaking on issues such as whether to evacuate, where to locate new construction, and whether to implement known mitigation measures in existing communities.

With this background, my following remarks address the Committee's questions for this hearing.

1) Is the United States growing more or less vulnerable to damage from wind hazards, and why? What are some of the top opportunities for, and primary barriers to, reducing these vulnerabilities?

The U.S. has grown more vulnerable to wind hazards because of two trends.

First, increasing development near the Atlantic and Gulf coast has created large populations and infrastructures that are vulnerable to hurricanes. The impact of this development is clearly indicated in the historical trend of insurance payouts for U.S. hurricane losses (see Figure 1). Starting in the early 1980's, the data show increasing losses with time, with an extremely large peak in 1992, associated with Hurricane Andrew. Today, almost all hurricane warnings require huge evacuations with attendant logistical problems and economic losses. In 1999, warnings for Hurricane Floyd resulted in the largest peacetime evacuation in the United States as 3 million residents along the Atlantic coast moved inland from Florida to North Carolina.

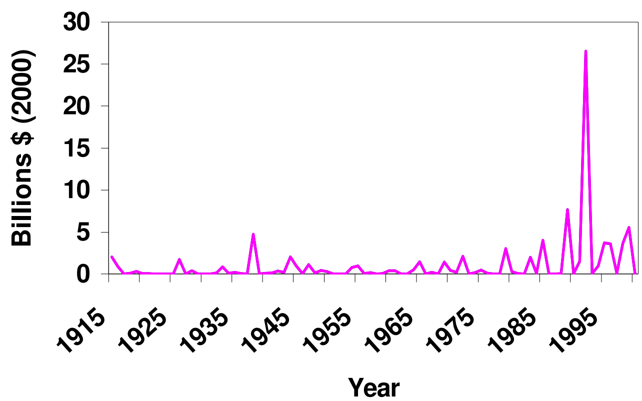

Figure 1 U.S. Hurricane Losses (1915-2000)

Data on insured hurricane losses, from the insurance industry, provide a stark measure of the increasing vulnerability. From 1949 to 1999, catastrophic hurricanes in the United States caused direct insured property losses totaling $37.9 billion — or an average of $743 million per year. To allow comparisons over long time periods, the insurance industry adjusts these values accounting for inflation, population growth, and changes in real tangible wealth. On this basis, the average annual loss from 1944 to 1988 was $1.1 billion. From 1988 to 1999, the values were almost 4 times larger ($4.2 billion). A portion of the increase was driven by the payouts from Hurricane Andrew, which was the largest insured property loss from a natural disaster in U.S. history. Even if one excludes the losses from Andrew, the payouts are almost double the historical trends, suggesting that the increased payouts reflect increasing vulnerability in addition to any fluctuations in hurricane frequency.

The second trend is associated with the prevalence of manufactured housing in the central part of the United States, which is susceptible to tornados. Because these structures have only minimal wind resistance, and no basements, the injury rate is extremely high for occupants during high winds. Analyzing historical data, researchers at the National Oceanographic and Atmospheric Administration estimate that the tornado death rate is approximately 20 times higher for residents of manufactured housing compared to conventional structures. In the Midwest, manufactured housing represents approximately 10% of current construction.

The most important feature of these vulnerabilities is that they could be reduced through appropriate R&D efforts. For example, better understanding of hurricane wind fields after landfall could be used for improved design and engineering of coastal structures. And experiments and testing of manufactured housing could be used to design more resilient homes.

2) Approximately how much money does the federal government spend per year on wind hazard mitigation research and development? Where is this effort currently focused (i.e. direct vs. indirect research, engineering, economic, meteorological, etc.)? How could the federal wind hazard research and development portfolio be refocused or otherwise strengthened to improve mitigation in the United States?

Answers to these questions are contingent on the analysis of two subsidiary issues, both of which were considered in detail in the RAND study, *Assessing Federal Research and Development for Hazard Loss Reduction*.

1) What is the definition of government "research and development" spending?
2) What are the characteristics of R&D for "wind hazard mitigation"?

For the first issue, we utilized RAND's RaDiUS database which details R&D spending across the federal government, as defined and classified by the Office of Management and Budget. The OMB definition for research and development is "creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications" (OMB Circular A- 11). Excluded from this category are product testing, quality control, mapping, the collection of general-purpose statistics, experimental production, routine monitoring and evaluation of an operational program, and the training of scientific and technical personnel. This definition, however, is open to the interpretations of numerous individuals at a wide range of government agencies. OMB permits individual agencies a degree of liberty in determining which activities should be considered R&D, allowing each agency to use its own long- standing definition of R&D when reporting such activities to OMB. As a result, the activities that the Department of Interior considers R&D may not be classified as such by the National Science Foundation, whose definition of R&D appears more tightly tied to basic laboratory science.

For the second issue, we examined all federally funded R&D applied to natural hazards, and we considered the contributions to hazard loss reduction. For FY 2001, this analysis found that approximately 90% of all R&D funds address weather- related hazards, which includes wind, flooding, extreme temperatures, drought, and large storms. Within this category, most of the funding supports short-term forecasting efforts (e.g., weather prediction, hurricane tracking, etc).

Considering the goals of loss mitigation, this allocation is problematic because short-term forecasts only make limited contributions to loss reduction. Specifically, forecasts are most useful for evacuations (thereby saving lives), but they do very little to limit the destruction of property. Reducing these losses requires longer terms efforts, involving improved engineering, design, and planning for infrastructure construction.

Considering the purposes of this hearing, we differentiate R&D expenditures that support improved engineering and design of structures from those that are focused largely on meteorological applications and weather forecasting (see table below). Activities in the first category largely include wind engineering research, supported by the National Science Foundation and the National Institute for Standards and Technology. By comparison, the meteorological category encompasses a huge range of basic and applied research on the nature of the global climate system.

Agency R&D Funding for Wind Hazard Mitigation (FY 2001, thousands $)

Infrastructure Losses	
NSF	2,647
NIST	8,387
Subtotal	**11,034**
Meteorological Applications	
NOAA	272,297
NSF	254,594
NASA	198,650
DOT	30,341
Subtotal	**755,882**

With this framework, R&D expenditures addressed to infrastructure losses were $11,034,000 in FY 2001. By comparison, expenditures for meteorological R&D were almost 70 times larger ($755 million).

The difference in funding between infrastructure and meteorological R&D for wind hazards is consistent with one of the principal findings from the RAND study applied to all R&D on natural hazards. Specifically:

• *Much of the R&D spending supports short-term prediction capabilities.* Closer examination of the funding for weather-related hazard R&D shows

> that most of the effort is focused on short-term prediction efforts, which have limited loss reduction potential within the full range of losses from natural hazards. Prediction can generally move individuals out of harm's way, but R&D focused on long-term loss reduction strategies could improve the resilience of communities and infrastructure, protecting lives and property in a far more substantial way.

Because the policy recommendations from the RAND study were directed to this problem, we restate them here as a strategic framework for considering new R&D initiatives for wind hazards. Specifically, the government needs to address these issues to ensure that new R&D efforts make a meaningful contribution to loss reduction for wind hazards.

• *Establish a comprehensive national loss database.* Data on hazard losses are central for a host of concerns, including prioritizing R&D efforts, planning budgets for states and localities, developing contingency operations, and conducting cost-benefit analyses for specific measures that will allow policymakers to see the relative value of various R&D efforts and will help citizens to understand the value of implementing long-term mitigation procedures.

• *Utilize loss modeling to identify essential R&D.* Loss modeling, which simulates the impacts of potential disasters, can help determine which hazards generate the greatest avoidable losses, the effects of mitigation steps on loss totals, the time scale for losses, and the budget needs for vulnerable regions to prepare for a prospective hazard. These models hold great promise for prioritizing research needs by weighing the costs and benefits of various mitigation measures against the estimated losses from specific hazards.

• *Reorient R&D activities toward longer-term loss reduction efforts*. A shift to longer-term, less prediction-oriented efforts holds great potential for reducing losses. The development of technologies to strengthen the built environment can save lives, protect property, and dramatically reduce the costs of rebuilding after a disaster.

• *Increase the focus on technologies and information that will reduce infrastructure losses*. Damage to infrastructure—e.g., buildings, public roads and highways, bridges, water and sewer treatment plants, and emergency services—results in casualties as well as extensive economic losses. The development of improved technologies and information systems can help limit such losses. For instance, greater R&D focus on funding for communications and remote sensing capabilities, geographic information and global positioning systems (GPSs), and modeling and simulation techniques should lead to considerable damage reduction.

3) According to National Weather Service estimates, how much damage do wind hazards cause in the United States each year? How are these numbers compiled?

Each year, the United States suffers significant losses from wind hazards. In the spring, tornados wreak havoc in the Midwest. In the summer and fall, hurricanes come ashore, damaging coastal and inland communities. In the case of Isabel in September 2003, this included massive blackouts in cities hundreds of miles from the point of landfall.

Even though these events are detailed in the media, and they trigger large government relief efforts, we have only a limited understanding of the actual loss levels and how they vary with time. In this respect the problem of quantifying wind losses is a component of the larger challenge of quantifying losses from all natural hazards

The lack of accurate loss data and the implications for public policy have been noted in a number of recent studies from the National Academy of Sciences, the Heinz Center for Environment and Public Policy, and RAND. The origin of the problem can be traced to a number of factors:

- **Most of the data on wind and hazard losses are never collected or analyzed.**

  The largest collection of data on wind losses is maintained by the Property Claims Service (PCS), which tracks insurance industry payouts to policyholders following a disaster. While this is a valuable resource for understanding insurance industry losses, it is certainly not a complete picture of wind losses in the United States. Moreover, the database is only available to professionals in the insurance industry. Additional unmeasured components of wind losses occur in the following categories:

  Federal: A number of agencies provide disaster relief, but there is no centralized recording of these expenditures.
  Private charities: Organizations such as the Red Cross provide vital relief services, using donated and internal resources.
  State and municipal governments: These governments incur disaster losses in a number of forms, including relief payouts, overtime for emergency workers, and damage to municipal facilities.
  Individuals and private companies: These entities suffer losses which are unmeasured and uncompensated by the above sources.

- **Wind losses are driven by the climate, which is extremely variable from year to year.**

  As a result, the level of wind losses can vary tremendously from year to year. However, the origins of the variability are complex. Part of the problem is driven by inter-annual climate fluctuations, which produce large variations in the number of windstorms. For example, over the past 90 years, the annual number of hurricanes making landfall on the United States has ranged from 8 to 0. By comparison, the annual number of reported tornados has ranged from approximately 500 to 1500 over the past 50 years. However, these changes only explain part of the loss variations, because the loss levels are also driven by event magnitudes and locations, which are uncorrelated with the number of storms in a given year. Hurricane Andrew emphasized this problem in 1992. The hurricane resulted in the largest insurance payments for any natural disaster in the United States ($15.5 billion), yet it occurred in a year with only an average number of storms.

- **In many cases, it is difficult to identify unique "wind" losses.**

  Except for tornados, most wind hazards are accompanied by large amounts of precipitation (rain, snow, hail), which complicates the process of determining causes of the resulting damage. For example, wind may blow a tree over, but only because rain has softened the ground. Hurricanes are usually accompanied by large amounts of flooding and water damage. And hail may be especially damaging because it hits objects with high wind velocities. Even the detailed Property Claims Service loss database does not distinguish the different origins for these wind-related losses.

- **Our vulnerability to wind hazards is increasing**

  As a result, trends in wind losses are strongly influenced by societal decisions regarding the design and location for new infrastructure. These issues are discussed in greater in response to Question 1.

- **There are ambiguities in the way that wind and hazard losses are characterized**

  While losses are usually reported as an aggregate number, it is important to distinguish the types of losses in an economic context. At the top level, the most important distinctions are between "direct" and "indirect" losses. The first category refers to losses that are directly associated with the damage (e.g., a house that is destroyed by a tornado), while the second involves the secondary effects of a disaster (e.g., someone looses his job because the disaster impacted his employer). From a measurement standpoint, the direct losses are much easier to quantify, and they only occur around the time of disaster. In contrast, indirect losses are somewhat subjective, and they are spread out in time, as the impacts of a disaster ripples through the economy. Although they are rarely discussed, benefits offset some of these losses (e.g., economic benefits of rebuilding damaged infrastructure). Considering all of these loss categories, the clearly are challenges to making an accurate and complete measurement of the losses for a particular hazard.

Considering the above factors, the current understanding of wind losses has been derived from a range of sources, with widely varying analytic techniques. As such, the results of this work are presented as estimates, rather than measurements of hazard losses. At this level of detail, the estimates cannot be used to assess the effectiveness of different R&D

strategies. However, they do provide a top-level description of the loss magnitudes and the variation among different types of hazards. With this background, the estimated annualized losses for wind related hazards, from a variety of sources, are presented in the following table.

Estimated Annualized Losses For Wind-Related Hazards	
Hazard	Estimated Annualized Loss ($ Billions)
Hurricanes	5.0
Winter storms	0.3
Tornadoes	1.0
Hail	0.7
Total	**7.0**

A central recommendation of the RAND study emphasized the need to improve the accuracy of these data to provide better guideposts for federal R&D policy related to natural hazards.

I appreciate the opportunity to be here today.